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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MEMORANDUM

DATE: April 14, 1992

SUBJ: Review of Technologies as Alternatives to Incineration
for Treating Hot Spot Sediment

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TO: New Bedford Harbor Superfund File

This memorandum is a brief description and evaluation of four technologies suggested as possible alternatives to incineration for treating the sediments from the Hot Spot area of New Bedford Harbor. The four technologies are: (1) thermal gas-phase reductive dechlorination, (2) APEG-plus dechlorination, (3) thermal desorption, and (4) base-catalyzed dechlorination. Congressman Gerry Studds arranged a roundtable discussion among EPA and representatives of the three commercially available technologies on March 5, 1992 at the Chamber of Commerce building in New Bedford. A fourth technology, base-catalyzed dechlorination (BCD), currently is not available through a commercial vendor. Nonetheless, BCD is included in this evaluation because both the community and the Congressman's office expressed interest in an evaluation of its potential for treating the Hot Spot sediments. This memorandum is a compilation of information from EPA reports, vendor brochures, and data supplied by the Risk Reduction Engineering Laboratory of EPA's Office of Research and Development, located in Cincinnati, Ohio.

To summarize what is known about these four technologies in comparison to incineration:

1. The four alternate technologies are all considered innovative technologies and would comply with the preference for innovative technologies in CERCLA Section 121(b).
2. With the exception of thermal desorption, the alternate technologies require that the untreated sediments undergo a screening step to remove larger particulates prior to treatment. Because of the extraordinary PCB contamination of the Hot Spot sediments, this additional handling of untreated sediments has a high potential for producing PCB releases to the atmosphere through volatilization. Thermal desorption, the alternate technology that does

not require a screening step, separates the PCBs from the sediments, but does not treat the PCBs.

3. All of the alternate technologies claim that they do not produce toxic emissions, however, the processes all require some heating and mixing of the waste which will induce additional volatilization of the PCBs. It is not clear that the alternate technologies incorporate sufficient air pollution control mechanisms to abate the emissions that may be produced when handling and/or treating the extreme PCB concentrations of the Hot Spot sediments.
4. The vendors for the three commercially available technologies indicated unit costs significantly lower than for incineration. However, because the alternate technologies have had few, if any, full-scale field demonstrations, these costs are difficult to predict accurately. In fact, the two technologies which have been employed in Superfund remedial actions were unable to complete treatment at the predicted rates, and consequently, had significantly higher unit costs than were anticipated.
5. Even if the alternate technologies did produce the promised savings in unit costs, there would be significant costs required to implement the necessary changes to the Record of Decision and current remedial design. These costs would significantly reduce, and probably eliminate, any overall cost savings in implementation of the remedy.
6. Incineration has a long history of use which has provided the necessary full scale field experience to finetune the process with different contaminant levels and matrices. The extensive utilization of incineration for destruction of PCB contaminated materials and PCB oils has provided the necessary field experience to develop effective and reliable process controls. This field experience has been used to develop and refine extensive regulatory controls which minimize health and safety risks to workers and nearby inhabitants.

THERMAL GAS-PHASE REDUCTIVE DECHLORINATION (Eco-logic)

In the Eco-logic process the waste is first screened so that it can be fed into the reactor via atomizing nozzles. The reactor is purged of air and charged with hydrogen prior to

introducing the waste. The reactor contains two "glo-bars" which act as a heat source. The temperature in the reactor is variously reported between 850°C and 1000°C, which would cause PCBs to volatilize into the gaseous phase. The dechlorination reaction occurs between the hydrogen and gas-phase contaminants to produce hydrogen chloride, methane, and ethylene. The methane and ethylene can then be recycled to a boiler which preheats the reactants. Residuals requiring disposal include the solids removed by the initial screening, the inorganic ash and/or slag, scrubber decant water, and scrubber sludge. There currently is one processor which has a capacity of 7-10 tons/day. The Eco-logic process has been used successfully on a (non-chlorinated) PAH contaminated sediment in Hamilton Harbor, Ontario. An EPA SITE demonstration of the Eco-logic process on a complex oily waste containing up to 5900 ppm PCBs is scheduled in Bay City, Michigan, during the summer of 1992.

Advantages

1. This process breaks the bonds in the organic contaminants, and combines the resulting fragments with hydrogen. The ultimate end products are methane, ethylene, and, in the case of a chlorinated contaminant, hydrochloric acid.
2. There isn't any need to separate solids from liquids at completion of the process because the chemical reaction (dechlorination) occurs in the gas phase.
3. The process is designed to react the organic constituents of the waste with hydrogen. The vendor claims that dibenzodioxins and dibenzofurans (which result from reaction with oxygen) are not produced, however, data to validate this claim on a concentrated waste with high water content is not currently available. (See disadvantage number 6, below.)
4. A water content of 30-50% is optimal for this process. The vendor explains that the water content serves as an additional source of hydrogen.
4. The end products of hydrocarbon (such as PAH) treatment may be recycled as fuel for pre-heating the waste, increasing the energy efficiency of the process.
5. The process has been demonstrated in the field (Hamilton, Ontario) on sediment with up to 3% PAH (non-chlorinated) contamination.
6. A gas-chromatograph continuous emission monitor which analyzes for 26 chlorinated and non-chlorinated organic contaminants is an integral part of the process. If this indicates products of incomplete reaction, the gases are recycled into the reactor.

Disadvantages

1. This process has not been utilized in the United States, and has not yet had a verification of its test results and claims by the EPA. An EPA SITE demonstration scheduled for June 1992, is currently behind schedule, and a report probably will not be available for a year and a half or more.
2. The process has been field tested in Canada on high concentrations of non-chlorinated PAHs and on PCB concentrations up to 110 ppm. (The Hot Spot sediments have a PCB content of 4000 ppm to over 200,000 ppm.) The concentration of hydrochloric acid that would result from using this process to treat the Hot Spot sediment might corrode/interfere with the glo-bars and/or the reactor vessel.
3. The reactant used in this process, which would have to be brought to the site and temporarily stored on-site, is pressurized hydrogen, itself a hazardous material because of its explosive potential. The exceptionally high PCB content of the Hot Spot sediments would require that a commensurate amount of reactant to be brought to the site.
4. The process has been tested only on the laboratory scale at PCB concentrations of 500 ppm or more. (PCB concentrations in the Hot Spot sediments range from 4000 ppm to over 200,000 ppm.) 9
5. The operating temperatures of the reactant vessel are sufficient to vaporize mercury, selenium, cadmium, and lead. No reports are given indicating the fate of these metals when subjected to this process.
6. The vendor indicates the hydrogen component of any water introduced with the waste is a source of hydrogen reactant. This logically leads to the conclusion that some oxygen radicals are released from the water, which have the potential to react with PCBs to form chlorinated-dibenzodioxins and chlorinated-dibenzofurans. No data is available on this potential problem.
7. Problems experienced in the first field utilization of this process included breaking of the glo-bars in the reactor and slagging of the waste solids in the bottom of the reactor. Adjustments in the reactor configuration and in process temperatures have probably solved these problems.
8. This process is not designed to treat the metal contaminants,

but has the potential to chemically change metallic ions and compounds. The chemically reduced form of these metals may be more toxic than the oxidized form.

APEG-plus dechlorination (Galson Research Corporation)

The APEG-plus process is a refinement of the KPEG-plus process that was bench (laboratory) scale tested on sediments from New Bedford Harbor in 1987. The waste material is screened to remove solids greater than 0.25 inch in diameter, and then introduced to the batch reactor vessel. The reagents poly-ethylene-glycol (PEG) and an alkali metal hydroxide (NaOH or KOH) are introduced to the reactor. The "plus" refers to the addition of a surfactant, in this case dimethyl-sulfoxide (DMSO). The reactor is heated to between 150°C and 180°C and the contents are thoroughly mixed by a stirring mechanism. The process continues until the required level of dechlorination (contaminant destruction) is achieved, as indicated by samples taken from the reactor at regular intervals. The batch of material is then centrifuged to separate the solid and liquid components and the recovered liquid PEG is recycled to treat the next batch of waste. The brochure describing the process notes that, "The ability to recycle reagent is the key to financial success of this system." The recovered solids are typically water washed prior to being reused on the site as fill material. The wash water also requires treatment.

Advantages

1. This process was used full scale at the Sol-Lynn Superfund site in Texas, so problems with mechanics and process control that often result when scaling-up from pilot scale to full scale have been addressed.
2. The process has had extensive EPA review and oversight, including treatability studies, an EPA SITE demonstration, and the Sol-Lynn Superfund remediation noted above.
3. There is a full-scale unit which is reported by the vendor to be capable of treating 200 tons/day of waste.
4. This process chemically dechlorinates the PCBs, leaving relatively nontoxic end products (biphenyl-ethers) and chloride salts.
5. This process occurs at low temperatures that are not expected to vaporize metal contaminants.

Disadvantages

1. The use of DMSO may lead to the formation of highly flammable volatile organics (e.g., methyl sulfide). Also, DMSO may create a severely corrosive situation.
2. The process requires that hazardous materials (caustics to create the alkaline conditions, and acids to neutralize the end products) be brought to the site. The amount of caustic and acid required is proportional to the PCB concentration of the waste.
3. Process residuals include washwater which usually can be discharged to a municipal wastewater treatment plant, the treated soils, and residuals from vapor treatment, usually activated carbon. Activated carbon residuals are generally taken offsite for incineration.
4. During the remediation at the Sol-Lynn Superfund site with this process, the actual through-put rate was about 50% less than anticipated, with a consequent increase in per unit costs.
5. At Sol-Lynn there were problems separating fine solids (clays) from the PEG reactant at completion of the chemical treatment. This caused a commensurate reduction in the amount of PEG reactant that could be recycled and a consequent increase in per unit costs. (Hot Spot sediments are 65% silt and clay on a dry-weight basis.)
6. As the water content of the waste increases above 15%, the amount of reactants (PEG, NaOH, and DMSO) that must be utilized to treat the waste increases, with a commensurate increase in per unit costs. (Dewatered New Bedford Harbor sediment has a water content of 40-50%.)
7. As the contaminant concentration of the waste increases, the amount of reactants (PEG, NaOH, and DMSO) that must be used to process the waste increases, with a commensurate increase in per unit costs.
8. The presence of other alkaline-reactive metals which may be reactive at the conditions of APEG treatment, add to the demand for reactants, causing a commensurate increase in per unit costs.
9. The APEG treated solids from a Superfund soil remediation project (Wide Beach, N.Y.) developed a "pudding-like" consistency when combined with water, making them unsuitable for backfilling. It is thought that this is a consequence of the high fines (clay) content of the treated soil. (Hot Spot sediments have a 65% fines content.)
10. This process does not treat metallic contaminants.

THERMAL DESORPTION (Soil-tech Taciuk process)

The Taciuk process was designed to extract oils from tar-sands. The processor consists of a reactor with four zones; preheat, reaction, combustion, and cooling. The waste is heated to 260°C in the preheat zone to drive-off water and volatile organic compounds. The waste material then passes through a patented sand seal to the "reaction" zone where it is further heated to temperatures of 370°C to 570°C. The added heat energy breaks some of the hydrocarbon bonds and the low oxygen allows only partial combustion, or "coking" of hydrocarbons. The waste then passes through a second sand seal into the combustion zone where the coked solids are heated to 600°C to 815°C to complete combustion and recover the remaining heat energy for recycling to the preheat zone. The process diagram indicates three air pollution control trains; from the preheat zone, the reaction zone, and the combustion (coked) zone flue.

The Taciuk process is used primarily on nonchlorinated hydrocarbons, although it was combined with the APEG process to treat soils with PCB levels up to 120 ppm at the Wide Beach, N.Y. Superfund site. There is one full-size unit with a capacity of 6-10 tons/hour. This unit is currently being used at the OMC Superfund site on Waukegan Harbor (Illinois). At the OMC Superfund site, the Taciuk processor has successfully desorbed 10,000 ppm PCBs from soil. The desorbed PCBs will be recondensed for transport to an off-site incinerator.

Advantages

1. There is a full scale unit commercially available, and the processor has been utilized to remediate one Superfund site, with another Superfund remediation underway.
2. The Taciuk process is very energy efficient, with a commensurate cost savings.
3. The relatively high temperature of the Taciuk process removes organic compounds from the solids residuals resulting in a dry solid that can be successfully backfilled.

Disadvantages

1. The Taciuk processor does not destroy PCBs. The PCBs are collected as an oily condensate and shipped off-site for treatment (usually incineration). The concentrated PCB oil must be manifested in accordance with RCRA to be shipped off-site. The costs of transport and incineration at a TSCA-permitted facility must be included to accurately reflect per unit treatment costs.
2. The Taciuk process decreases in energy efficiency as the water content of the waste feed increases above 10%, thereby

decreasing the cost efficiency. (Dewatered sediment from New Bedford Harbor has a moisture content of 40-50%.)

3. A high fines content may reduce the expected throughput rates, resulting in increased per unit costs. (Through-put rates at the Wide Beach Superfund site were significantly less than anticipated, presumably because of the high clay content. Sediments from the Hot Spot are 65% silts and clay.)

4. The Taciuk process includes a combustion zone, and at high PCB loadings, products of incomplete combustion (dibenzodioxins and dibenzofurans) may be formed.

5. The temperatures in the combustion zone are sufficient to vaporize mercury, arsenic, cadmium and lead. Data on the fate of these metals in the Taciuk processor is not currently available.

BASE-CATALYZED DECHLORINATION (BCD)

The Base-catalyzed dechlorination (BCD) process was developed at EPA's Risk Reduction Engineering Laboratory in Cincinnati, Ohio, as a refinement of the APEG process. The process is expected to be less expensive than APEG because it requires less PEG reactant and operates at lower temperatures (320-350°C). It has been demonstrated on high PCB contaminant levels in the laboratory. It has not yet been demonstrated in the field. A pilot scale plant has been tested on non-contaminated, dry soil by the U.S. Navy and is currently enroute to Guam for testing on soils contaminated with 25-1000 ppm PCBs. The process is not yet licensed to a commercial vendor, i.e., the only unit belongs to the U.S. Navy.

Advantages

1. The BCD process destroys PCBs and testing of the reaction residuals has indicated they are nonmutagenic.
2. The relatively low operating temperatures result in low energy requirements and a commensurate cost savings.
3. Because the process does not involve combustion, the probability of producing dibenzodioxins and dibenzofurans is very low.
4. The low temperatures of this process exceed the boiling points of mercury, cadmium, and arsenic. However, lead would not be expected to vaporize during BCD processing.

Disadvantages

1. The BCD process has not been demonstrated on contaminated

material outside of the laboratory. It is probable that problems will arise in scaling-up the process and providing all the ancillary processes such as waste feed handling, off-gas treatment, separation of solid and liquid residuals, and PEG recovery and recycling.

2. Field testing of the process is approximately a year behind schedule.
3. The process is not yet licensed to a commercial vendor. Licensing often takes a year or more.
4. It is probable that the process efficiency and/or processing rates will be reduced in a waste with a high water content, such as a harbor sediment.
5. This process does not treat metallic contaminants.
6. There has not been an opportunity to observe and test this process in the field, in order to provide a sizeable volume of waste residuals and emissions to analyze for byproducts of incomplete reaction.

INCINERATION (Rotary kiln)

There are three types of transportable incinerator that can meet the performance requirements for treating the Hot Spot sediments: rotary kiln, infra-red, and fluidized bed. There are at least a dozen transportable incinerators that meet the through-put requirement of 7 to 10 tons/hour. Most of these are of the rotary kiln type.

A rotary kiln incinerator consists of an inclined cylinder lined with a refractory material that is heated to temperatures ranging from 750°C to 1000°C. A rotary kiln can accept waste in liquid or solid form. Waste residence time in the kiln ranges from 0.25 to 1.5 hour. The hot gases from the rotary kiln exit to a secondary combustion chamber where the temperature is increased to 1100°C to 1350°C and excess oxygen is provided to insure complete combustion. The hot gases are then transported through a series of air pollution control units to cool the gas stream, neutralize acid gases, and remove fine particulates and metals.

Advantages

1. There is extensive field experience using this technology to treat hazardous organic wastes, especially PCBs. Materials handling processes and process mechanics are minimal, and are well established.
2. The process is considered Best Available Demonstrated

Technology by EPA under the RCRA and TSCA regulations, and sets the standard for other technologies. Incineration is the only technology currently available that has been demonstrated to destroy PCBs at the concentrations found in the Hot Spot to the required cleanup levels.

3. An incinerator is required to demonstrate 99.9999% destruction and removal efficiency (DRE) in a trial burn on a sample of the waste to be treated prior to being permitted. This ensures that the 99.9999 % DRE will be met, and establishes the operating parameters for the incinerator when treating that particular waste. Emissions of toxic metals, acid gases, particulates, and products of incomplete combustion (PICs) are also measured during the trial burn to ensure that these emissions do not exceed EPA and state risk limits.

4. The residuals, including stack emissions, from this technology have been more extensively analyzed than for any other technology. The attendant risks are well characterized and are controlled through various regulatory requirements on combustion efficiency, and emission of acid gases and particulates. The requirements for continuous monitoring of combustion efficiencies ensures the 99.9999 % DRE and reduces to a minimum the potential formation of PICs including dibenzodioxins and dibenzofurans. The incinerator is required by EPA regulation to automatically cutoff feed if the continuous monitoring indicates the incinerator is operating outside the parameters established during the trial burn. The incinerator operator must demonstrate, using approved EPA air dispersion models and local meteorological data, that the incinerator emissions of metals and PICs will not pose an excess lifetime cancer risk of greater than 1 in 100,000 to the most exposed individual. Data from actual trial burns at Superfund sites indicate that the requirements for maximum particulate emissions are effective in reducing metal emissions to below levels allowed by ambient air limits.

5. The unit costs for this technology are well established and known because of the extensive field experience incinerating hazardous organic wastes.

6. The ash from the incinerator is a dry solid physically suitable for use as backfill.

7. The Record of Decision (ROD) indicates incineration is the treatment method to be utilized for the Hot Spot sediment. Any other treatment method would require a new proposal, public comment period, and ROD. The process of re-doing the ROD could easily take a year or more to complete.

8. Proposals have been submitted for remediation of the Hot Spot which include incineration of dredged and dewatered sediments. A decision to use a treatment technology other than incineration

would require that this procurement process be aborted. After the re-RODing process was completed (see number 7, above), a new design could be initiated. The design process usually takes more than a year to complete. Procurement, which often takes a year or more for a project this complex, would have to wait until after the design was complete.

Disadvantages

1. Incineration is more expensive on a per unit treated basis than is estimated for the other technologies. Energy requirements and attendant costs increase as water content exceeds 15%. (New Bedford Harbor sediments have a water content of 40% to 50%, after dewatering.)
2. Incineration does not treat metal contaminants. Some toxic metals may be vaporized (mercury, arsenic, cadmium, and lead) at the high operating temperatures of a typical TSCA incinerator. However, the incinerator operator must demonstrate that these emissions will not expose the maximum exposed individual to a lifetime risk of more than 1 in 100,000.
3. Caustic materials used to neutralize the acid gases must be brought to the site.
4. As in all of the processes, the solid residual (ash) may require additional treatment to prevent leaching of toxic metals in excess of the TCLP limits.

CONCLUSION:

Because of the uncertainty associated with the use of an emerging technology, it is difficult to predict what the associated risks might be. This is particularly true for technologies which have not been tried at full scale, which is the case for two of the technologies discussed above. In a situation with the potential for high human exposures, such as exists during the removal and treatment of the Hot Spot sediments, it does not seem appropriate to accept these ill-defined risks when a treatment technology (incineration) that has proven itself reliable and safe when properly managed is available. Therefore, it is recommended that EPA proceed to implement its April 6, 1990, decision to treat the sediments from the Hot Spot of New Bedford Harbor by incineration.

REFERENCES FOR TECHNICAL MEMORANDUM ON ALTERNATE TECHNOLOGIES

1. Innovative Technologies, Overview and Guide to information Sources, U.S. EPA Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/9-91/002; October, 1991.
2. personal communications with Ben Blaney, Chief, Superfund Technology Demonstration Division, Technical Support Branch, Risk Reduction Engineering Laboratory, EPA Office of Research and Development, Cincinnati, Ohio. Also contacted through Mr. Blaney were Paul de Percin for information on APEG-plus and Taciuk; Gordon Evans for information on Eco-logic, and Dr. Alfred Cornell for information on Base-Catalyzed Dechlorination.
3. Vendor brochures supplied by:
Eric Eidsness of Soil-tech, Inc.
Dr. Wayland Swain of Eco-logic, Inc.
Dr. Robert Peterson of GRC Environmental, Inc.
4. Trial-burn report from the Bridgeport Rental and Oil Storage (BROS) Superfund Site in Bridgeport, New Jersey.